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T.O. 31R2-2FRC-192
(Formerly AN 16-35T4-11)

HANDBOOK
SERVICE INSTRUCTIONS

RADIO TRANSMITTERS
T-4/FRC AND T-5/FRC

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<i>Page No.</i>	<i>Date of Latest Revision</i>
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6	1 November 1956
21	1 November 1956
40	1 November 1956
51	1 November 1956
81	1 November 1956
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137-138	1 November 1956
139-140	1 November 1956
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1-2. REMOTE-CONTROL EQUIPMENT.

1-22. In the typical installation, each of the four remote operator positions is provided with a switch panel and an oscillator. The switch panel enables the operator to select for operation any one of the five transmitter channels; while the oscillator, into which a key can be plugged, sends a keying tone to the selected transmitter. In addition, operator 1 and operator 2 positions are each provided with an amplifier and an additional oscillator. The amplifier is used to increase the microphone output and feed a channel of the modulator; the additional oscillator is used to provide m-c-w tone when m-c-w operation of the transmitter is desired. Although operator 1 and operator 2 positions have master control of the modulator channels, temporary control may be transferred to either of the other positions by means of the OPERATOR SELECTOR switch.

1-23. Remote Control Console CY-161/FRC can be used as an alternative control equipment to that described above. For specific instructions on the use of this component, refer to the applicable handbook.

1-24. TRANSMITTING RANGE.

1-25. The 1-f transmitter (150-550 kilocycles) provides a channel which may be used for long-distance point-to-point service. Propagation within this frequency range is reliable. Moderate distances can be covered by use of the ground wave, the range of which is affected only slightly by atmospheric conditions. For long-distance communication, the sky wave must be used. Distances covered by the sky wave vary from day to day and from season to season; the greatest ranges being obtained in the winter nighttime hours. Atmospheric conditions during the daylight summer hours are generally such as to render sky-wave communication impossible, especially at the higher frequencies.

1-26. The h-f transmitter (2-18 megacycles) provides line-of-sight, moderate-distance, and long-distance communication of all types. Line-of-sight transmission within this frequency range is very reliable. Moderate and long-distance transmission depends solely upon sky waves which are affected greatly by atmospheric conditions. Under certain conditions, a transmitter operating in this frequency range may send a signal around the earth. Under adverse conditions, such as occur during severe ionospheric storms, other than line-of-sight communication will approach the impossible.

1-27. EQUIPMENT COMPONENTS.

1-28. Table 1-1 lists the quantity, official nomenclature, common name, and weight for each component of a typical installation. Also included in this table are dimensions and numerical series of reference designations.

1-29. CABLE ASSEMBLIES.

1-30. Table 1-2 lists the cable assemblies required for transmitter installations. All cable assemblies are shipped in the cable ducts.

1-31. DESCRIPTION OF COMPONENTS (TRANSMITTING EQUIPMENT).

1-32. The transmitting equipment is housed in cabinets constructed of welded steel angles and sheet-steel panels. All cabinets are the same height and are designed to provide a uniform appearance when assembled in group installation. In a normal installation, the various cabinets are bolted together to form one composite equipment, with the power rectifier in the approximate center. Wire ducts are provided to accommodate intercabinet wiring, and access to the ducts is obtained through a front cover plate in the base of each cabinet. A typical transmitting equipment installation is shown in figure 1-2.

TABLE 1-1. EQUIPMENT COMPONENTS

Quantity Per Installation*					Name of Component	Army-Navy Type Designation	Common Name	Over-All Dimensions (inches)			Weight (pounds)	Numerical Series of Reference Designations
A	B	C	D	E				Height	Width	Depth		
TRANSMITTING EQUIPMENT												
4	4	3	2	1	Radio Transmitter	T-4/FRC	H-F transmitter	61	12	24	330	1-99
1	0	0	0	0	Radio Transmitter	T-5/FRC	L-F transmitter	61	18	24	450	301-399
1	0	0	0	0	Antenna Tuning Unit		Antenna tuning unit	50	40	39	193	301-399
1	1	1	1	1	Modulator	MD-1/FRC	Modulator	61	12	24	510	101-199
1	1	1	1	1	Power Rectifier	PP-1/FRC	Power rectifier	61	50	24	690	201-299
REMOTE-CONTROL EQUIPMENT												
4	4	3	2	1	Switch Panel	SA-2/FRC	Switch panel	3½	19	4	5	401-499
6	6	5	4	2	Oscillator	O-2/FRC	Oscillator panel	3½	19	9½	15½	501-599
2	2	2	2	1	Amplifier	AM-2/FRC	Amplifier panel	3½	19	9½	16½	601-699
					Remote Control Console**	CY-161/FRC	Control console	72	44	32½	177	1-99

* See figure 3-1

** Auxiliary equipment

TABLE 1-2. CABLE ASSEMBLIES REQUIRED FOR TRANSMITTER INSTALLATIONS
(Figure 3-1)

Quantity Per Installation					Army-Navy Type Designation	Length		Common Name	Remarks
A	B	C	D	E		Ft.	In.		
1	1	1	1	1	CX-1238/U	1	2¼	Armored cable	Connects modulator to power rectifier
1	1	1	1	1	CX-1239/U	30	0	Remote control cable	Wall terminal block attached to one end
6	5	4	3	2	CX-1240/U	1	8	Ground strap	One in each component
5	5	5	5	5	CX-1241/U	0	10	Patch cord	Ignition wire
1	1	1	1	1	CX-1241/U	3	6	High-voltage cable	Ignition wire
2	2	2	1	0	CX-1241/U	4	9	High-voltage cable	Ignition wire
2	1	0	0	0	CX 1241/U	6	0	High-voltage cable	Ignition wire
1	1	1	1	1	CX-1242/U	3	6	Interconnection cable	Connect transmitters to power rectifier
2	2	2	1	0	CX-1242/U	4	9	Interconnection cable	
2	1	0	0	0	CX-1242/U	6	0	Interconnection cable	
2	2	2	2	2	CX-1243/U	6	4	Single wire lead	In modulator
1	1	1	1	1	CX-1244/U	50	0	Emergency power cable	Two parallel pairs of conductors
1	1	1	1	1	CX-1552/U	1	7	Interconnection cable	Contents modulator to power rectifier

1-33. The power rectifier serves as the central component of the installation. It contains not only the high-voltage power supply but all the relays and controls required for local control of the equipment. A central blower system in this component draws air through an air filter and circulates it through air ducts to all transmitting-equipment cabinets for cooling purposes. Hot air is exhausted through a vent in the top of each cabinet.

1-34. The electrical stages of the h-f and l-f transmitters and the modulator are mounted on slide-out chassis to permit easy access for servicing, band changes, and inspection. Each slide-out chassis is connected by flexible cables to its respective cabinet plug board. The power rectifier does not have a slide-out chassis; however, the stages have been placed where they are accessible for inspection and servicing. Meters, indicator lamps, switches, output terminals, and door handles of all components are recessed to minimize the possibility of damage.

1-35. RADIO TRANSMITTER T-4/FRC (H-F TRANSMITTER).

1-36. The h-f transmitter (figure 1-3) is designed to provide a nominal power output of 400 watts cw, mcw, or voice, into a 600-ohm transmission line, at any frequency from 2 to 18 megacycles.

1-37. A plug board in the base of the cabinet contains the necessary receptacles for connection of control, power and high-voltage cables. Two tuning meters and a "channel on" indicator lamp are located at the top front of the cabinet. Necessary tuning controls are mounted on the front panel of the slide-out chassis, and are protected during operation by a cabinet door which can be kept closed.

1-38. Frequency change is effected by means of crystals, plug-in coils, and band-switching. The band switches,

together with the excitation control, are located on the lower-left side of the slide-out chassis. The r-f output to the transmission line is taken from the power-amplifier stage through the two insulated terminals on the top of the slide-out chassis. In order to pull the chassis all the way out, it is necessary to disconnect the r-f leads; and if operation is desired for any reason with the chassis pulled out, two alligator-clip leads are furnished with each transmitter to complete the connections to the cabinet from the slide-out chassis.

1-39. Frequency is normally controlled by crystal, although a master oscillator is provided for emergency use. A teletype jack is provided on the master-oscillator chassis for connection of a frequency-shift keyer.

1-40. RADIO TRANSMITTER T-5/FRC (L-F TRANSMITTER).

1-41. The l-f transmitter (figure 1-4) is designed to supply into an antenna tuning unit a nominal power output of 800 to 1000 watts, cw, mcw or voice, at any frequency from 150 to 550 kilocycles.

1-42. This component is similar in design to the h-f transmitter. The major differences between the two transmitters are in size, power, manner of band changing, and method of safety interlock. The l-f transmitter is six inches wider than the h-f transmitter, and employs four tubes in the power-amplifier stage, as compared to two in the h-f transmitter. Band changing is effected by linking capacitors into, or out of, the tuned circuits, and by adjusting the inductances through the use of coil taps. An automatic high-voltage disconnect switch and bleeder assembly is used in place of the safety interlock and interlock shunt switches of the h-f transmitter.

1-43. Tuning controls of the l-f transmitter are similar to the controls of the h-f transmitter; the major ones are front-panel mounted and plainly marked.

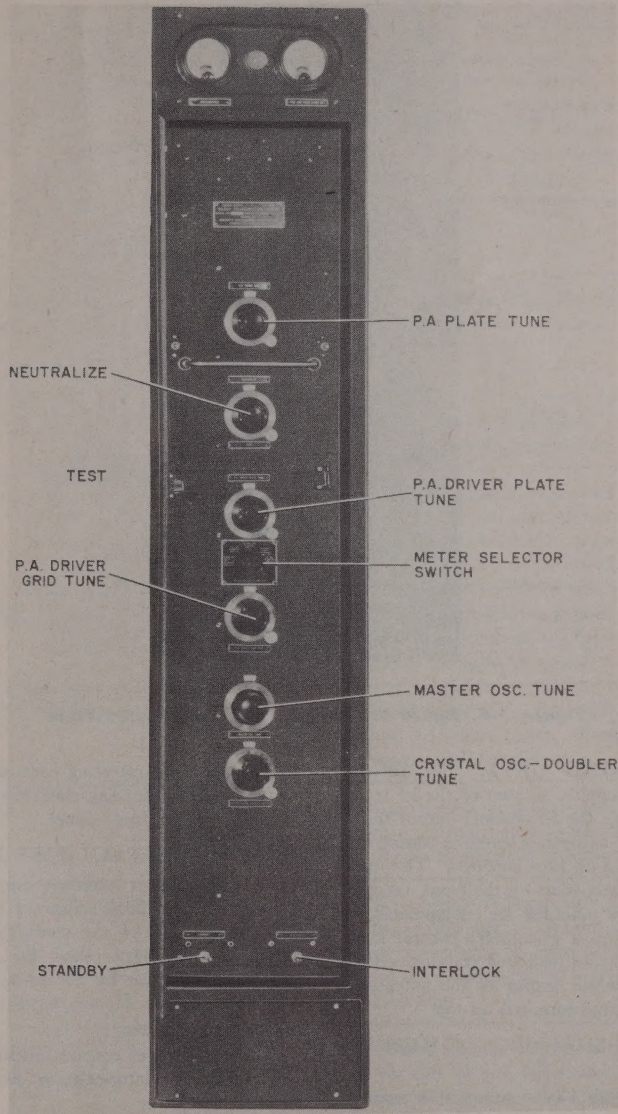


Figure 1-3. Radio Transmitter T-4/FRC, Front View

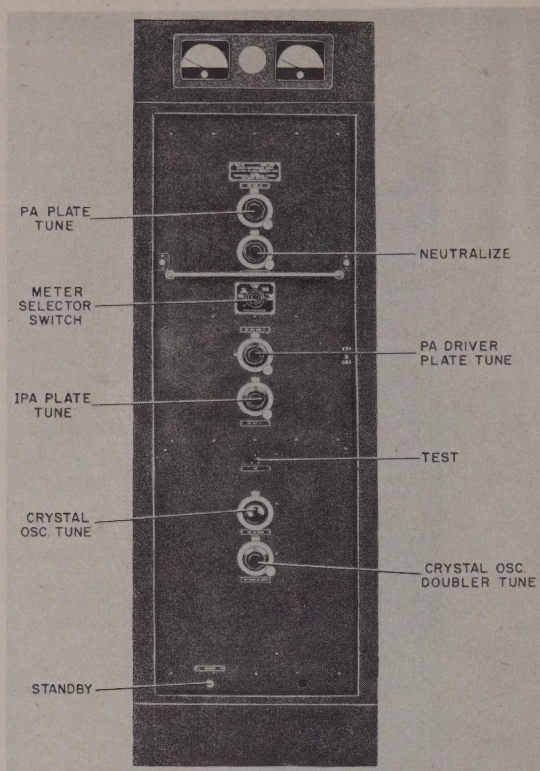


Figure 1-4. Radio Transmitter T-5/FRC, Front View

1-44. **ANTENNA TUNING UNIT.** The antenna tuning unit (figure 1-5) supplied as part of the l-f transmitter, is designed to couple the l-f channel output to the antenna. It consists of an adjustable antenna tuning coil in a metal housing mounted on four supports. The housing has outer and inner access doors on the front, together with a panel on which are mounted an r-f ammeter, an ammeter by-pass switch, and a variometer control knob. Input connection is made at an insulated terminal on the left side of the housing, while output to the antenna is taken from the large insulated terminal on top.

1-45. **MODULATOR MD-1/FRC (MODULATOR).**

1-46. The modulator (figure 1-6) contains two separate modulator circuits, each capable of supplying 300 watts of high-level, plate modulation to two transmitters, simultaneously. The two modulator channels contained in the modulator are identical, and each consists of three amplifier stages and a final power-modulator stage. The modulator contains its own low-power voltage supply, but derives high plate voltage for the modulator tubes from the power rectifier. For identification, the two modulator channels in the modulator are referred to in this handbook as modulator 1 and modulator 2, respectively.

1-47. Gain and metering controls, together with stand-by and interlock-shunting switches for the modulator, are located on the front panel.

1-48. **POWER RECTIFIER PP-1/FRC.**

1-49. The power rectifier (figure 1-7) provides high voltage to the final stages of each transmitter, and to the final stages of the modulator. In addition, it contains the necessary relays for control purposes, and a heavy-duty blower for forced-air cooling of the transmitter components. It also serves as a terminus for inter-component cabling.

1-50. Front-panel controls include local channel-selector switches, modulator-selector switches, and a main line circuit breaker.

1-51. **DESCRIPTION OF COMPONENTS (REMOTE-CONTROL EQUIPMENT).**

1-52. Different combinations of remote-control components are used at the remote-control site. Each of these components has a panel-type chassis suitable for mounting in a standard rack, not supplied as part of the equipment. One rack is required at each of the four remote-control operator positions. Each rack mounts one switch panel

TABLE 1-8 (Continued)

<i>Control Mark or Name</i>	<i>Reference Designation</i>	<i>Function</i>
RADIO TRANSMITTER T-4/FRC (Continued)		
ADJUST FOR 10 MA. P A DRIVER GRID CUR.	S9	Eleven-position selector switch on left side of pull-out chassis. Varies screen voltage to intermediate power amplifier, thus varying excitation to power-amplifier driver tubes.
RADIO TRANSMITTER T-5/FRC (Figure 1-4)		
MASTER OSC. TUNE	C301	Variable capacitor with dial and control knob on lower part of front panel. Tunes grid circuit of master oscillator.
CRYSTAL OSC.-DOUBLER TUNE	C312	Variable capacitor with dial and control knob on lower part of front panel. Tunes plate tank circuit of crystal-oscillator doubler.
NEUTRALIZE	C355 and C335	Ganged variable capacitors with dial and control knob on upper part of front panel. Neutralize effect of interelectrode capacitance in four parallel connected tubes in power-amplifier stage.
I.P.A. PLATE TUNE	L307	Variometer with dial and control knob on center part of front panel. Tunes plate tank circuit of intermediate power amplifier.
P.A. DRIVER PLATE TUNE	L309	Variometer with dial and control knob on center part of front panel. Tunes plate tank circuit of power-amplifier driver.
P.A. PLATE TUNE	L313	Variometer with dial and control knob on upper part of front panel. Tunes plate tank circuit of four paralleled tubes of power-amplifier stage.
MASTER OSC. BAND SWITCH	S301	Six-position selector switch, with control knob on lower left side of pull-out chassis. Each position of switch selects a master-oscillator frequency band, the six positions cover a frequency range of 150-300 kilocycles.
M.O.-CRYSTAL SWITCH	S302	Rotary selector switch, with control knob on lower left side of pull-out chassis. Selects means of channel frequency control; crystal, master oscillator, or teletype.
STANDBY	S303	A dpst toggle switch on lower left of front panel. Controls low power to transmitter.

TABLE 1-8 (Continued)

<i>Control Mark or Name</i>	<i>Reference Designation</i>	<i>Function</i>
RADIO TRANSMITTER T-5/FRC (Continued)		
TEST	S306	Three-position lever switches on front panel. Used to key the transmitter locally. Locks in the up position, has momentary action in the down position, and in center (normal) position it is disconnected. Used only during tuning operations.
METER SELECTOR SWITCH	S307	Two-section, 6-position selector switch on front panel. Switches milliammeter M1 into either the cathode or grid circuit of certain of the class C amplifier stages.
CRYSTAL OSC. DOUBLER BAND SWITCH	S308	Three-position selector switch, with control knob on lower left side of pull-out chassis. Each position of switch selects a crystal-oscillator frequency band; the three positions cover a frequency range of 2-6 megacycles.
ANTENNA TUNING UNIT (Figure 1-5)		
VARIOMETER FINE TUNING	L314	Variometer with control knob on front panel. Provides fine tuning of antenna tuning coil.
AMMETER BY-PASS	S309	An spst knife switch on front panel. Used for shorting-out r-f ammeter.
POWER RECTIFIER PP-1/FRC (Figure 1-7)		
S201	S201	Double-pole, thermally-operated, manually-reset, 50-amp circuit breaker on front of center shelf. Connects main power input to entire equipment, and should be left in the closed position at all times except when taking transmitter out of service.
LOCAL REMOTE	S202	A dpdt toggle switch on panel inside left front door. Selects local or remote operation of transmitting equipment.
FILAMENTS	S203	A dpst toggle switch on front panel, below CHANNEL switches. Connects filament power to transmitter, in local control only.
PLATE	S204	A dpst toggle switch on front panel. Controls plate power to entire transmitter.
TUNE OPERATE	S207	A dpdt toggle switch on panel inside left front door. Protects transmitter circuits during tuning operations. In TUNE position voltage applied to r-f channels is reduced sufficiently to prevent overloading. In OPERATE position full plate voltage is applied.

hard-drawn copper wire or copper-clad steel wire in fabricating the antenna. No. 10 B and S gauge, enameled, hard-drawn copper wire is the most suitable. Soft-drawn copper wire will stretch, thus changing the resonant frequency of the antenna after a short period of use, but if only soft-drawn wire is available, it can be made reasonably usable by stretching it before cutting to length.

3-81. The center-fed tuned doublet is matched with the h-f transmitter output by the transformer characteristic of the 600-ohm, open wire, delta-connected transmission line. This line should be constructed of two copper wires, enamel or tin-covered, and the two wires spaced several inches apart. To provide the desired characteristic impedance, the wire size and the spacing between the wires should adhere closely to those values given in table 3-5.

TABLE 3-5. TRANSMISSION-LINE WIRE SIZE AND SPACING

<i>Wire Size (B and S gauge)</i>	<i>Spacing Between Conductors (in.)</i>
8	9.50
10	7.75
12	6.25
14	4.75

Spacing insulators should be used as sparingly as possible, consistent with the proper maintenance of spacing, and should be of good, moisture-resistant, insulating material. Physically, the transmission line should be of the same specifications throughout its length except for that portion of the line nearest the antenna, which must be fanned out as follows:

3-82. At a distance from the antenna, in feet, calculated by the formula, 147.6 divided by the transmitter frequency in megacycles, the line should begin to fan out. The feeder wires should be attached at two points equidistant from the center of the antenna. The distance, in feet, from each end of the antenna to the point of connection of the nearest feeder wire is determined by dividing 175 by the transmitter frequency in megacycles. The other end of the feeder pair is connected to the 600-ohm output terminals of the high-frequency transmitter.

WARNING

The transmission line should be erected and maintained as high as is practicably possible to insure against accidental contact by personnel.

An advantage of this type of transmission line is that the feeder wires, providing an electrically balanced arrangement, and hence low feed-system radiation can be of any length up to several-hundred feet without incurring a serious loss of power.

3-83. VERTICAL MARCONI.

3-84. The choice of the type of antenna to be used for the low-frequency transmitter will depend on whether sky-wave operation or ground-wave operation is desired. A vertical Marconi type is recommended for sky-wave radiation. This antenna provides high-angle lobing characteristics that are useful where sky-wave transmission is preferred. Sky-wave transmission is not recommended in arctic latitudes. A suitable vertical Marconi type is provided by vertical tower, sixty feet or more in height, and insulated from the ground. It is desirable to use a tower as tall as possible, since radiation efficiency increases with increase in height. The antenna tuning unit should be mounted at the base of the tower, sheltered if possible, and connected to the antenna and transmission line as described in paragraph 3-39. To further increase the radiation efficiency of a vertical-tower antenna, a radial ground system can be constructed at the base of the tower. This system consists of approximately 12 copper conductors buried one or two feet below the surface and arranged in a radial pattern similar to the spokes of a wheel. The conductors are connected together at the center and used as the ground connection for the antenna tuning unit. To construct each of the ground radials, use No. 12 B and S gauge wire at least equal in length to the height of the tower.

3-85. FLAT-TOP.

3-86. An effective low-frequency antenna can be constructed of a single wire parallel to the earth, with one end connected to the antenna tuning unit by a vertical lead-in wire. For maximum efficiency, the combined length of the lead-in and the flat-top should be as long as possible, but not in excess of about 400 feet if it is desired to resonate the antenna using the antenna tuning unit alone.

Use No. 6 B and S gauge or larger copper wire to give adequate strength, and insulators large enough to support the weight of the wire; ten-inch insulators or larger are satisfactory.

3-87. POSTINSTALLATION CHECK.

3-88. MECHANICAL.

3-89. Throw all switches to OFF position. Examine all leads for loose connections and joints. Be sure all wires and plugs are properly connected. Make certain that all subassemblies are securely fastened. Rotate all selector switches through their various positions to see that they do not bind. Check blower motor for correct lubrication. Blower bearings should be oiled by filling the two oil cups on the fan and the two on the motor with engine oil, Specification MIL-O-2104 (ORD). Check antenna and transmission-line connections for tightness. Each transmitter must be either properly connected to an antenna, or must have a non-inductive load resistance of 500 to 600 ohms connected to its output terminals. If the frequency of the transmitter is to be crystal controlled, see that a crystal of the correct frequency is plugged into

the crystal-holder socket, and that the M.O.-CRYSTAL SWITCH is placed in the CRYSTAL position. Check the fuses in the fuse panels with the values given for them in tables 1-3 and 1-4. Check all relays for freedom of movement. See that each tube is in its correct socket, and that grid and plate leads are securely connected to their respective terminal posts.

3-90. ELECTRICAL.

3-91. TRANSMITTER INSTALLATION. Before applying power to the transmitter installation, place main line switch S201 and all seven toggle switches on the power rectifier in OFF position. Rotate both AUDIO GAIN controls on the modulator to the extreme counter-clockwise position. Place TEST keys of all transmitters in center position. Place LOCAL-REMOTE switch in LOCAL position. Place TUNE-OPERATE switch in TUNE position. Place STANDBY switches on all components in ON position, and INTERLOCK shunt switch of h-f transmitters in OFF position. Roll all pull-out chassis back into their cabinets. Connect power-line plug to receptacle at rear of power rectifier. Throw main-line switch to ON position. Turn FILAMENTS switch to ON position. Relay E201 on relay and fuse panel should close, and green indicator lamp on power rectifier should light, indicating that filament power circuits are energized. Check cycling time of time-delay relay to see that it is approximately one minute. After this time has elapsed, blower motor should automatically start; listen for the characteristic sound. Throw PLATE switch to ON position. Listen for closing sound of heavy-duty, plate-power contactor. Red indicator lamp should light. With power-rectifier FILAMENTS switch in ON position, STANDBY switch of each transmitter and the modulator in the right-hand position, and all CHANNEL switches in the OFF position, observe tube filaments in all components. All except the JAN 810 and the JAN OC3/VR105 tubes should be lighted.

3-92. REMOTE CONTROL INSTALLATION.

Place POWER switch on Switch Panel SA-2/FRC in down position. The corresponding red indicator lamp at all four remote operating positions should light. This indicates to all operators that power is supplied to the switch panels. Plate voltage in the power rectifier is applied when the time-delay relay has cycled. This occurs automatically about 60 seconds after the switch panel POWER switch has been placed in the down position. Choose one of the five channel selector switches on the switch panel for channel-selection testing. When CHANNEL 1 switch is placed in the down position, CHANNEL 1 indicator at each remote operating position should light, providing an indication to all operators that the channel is in use. All other channels can be checked in the same manner.

CAUTION

If the transmitter is operating in locations where the ambient temperature may be below 0° C (32° F), the remote POWER switch should be turned on a minimum of two minutes, before a channel-selector switch is pushed down. This procedure aids the mercury-vapor tubes in reaching a normal operating state before the application of the ionizing voltage.

3-93. Place POWER switch of tone-keying Oscillator O-2/FRC in ON position. This oscillator is mounted nearest the switch panel (figure 1-9). Plug telegraph key into KEY jack of tone-keying oscillator panel. Actuate the telegraph key and note that transmitter keys consistently. If unsatisfactory keying is apparent, refer to paragraph 5-68 for adjustment of the keyer gain control. Place POWER switch on the other Oscillator O-2/FRC in ON position. This is the m-c-w oscillator panel and is mounted directly above the tone-keying oscillator panel. After selecting a modulated channel in accordance with patch panel connections, plug a telegraph key into KEY jack of m-c-w oscillator, and test-key the transmitter in the same way as for the test for the tone-keying oscillator panel. For this test, the MODULATOR PLATE meter should indicate 250 milliamperes, under the closed-key condition. If this test is not satisfactory, refer to paragraph 6-28 for adjustment of the GAIN control of the modulator channel in use.

3-94. Place POWER switch on Amplifier AM-2/FRC in ON position. Plug a microphone into the MIC MOD. 1 or the MIC MOD. 2 jack on switch panel. Use the jack designated for the modulator channel which is to be used. Press push-to-talk switch on microphone, and while talking into the microphone, observe the deflection of the MODULATOR PLATE meter. If this deflection is not 250 milliamperes on modulation peaks, refer to paragraph 5-71 for adjustment of the AUDIO GAIN control for that modulator channel. The remote-operating position is now adjusted for c-w, m-c-w, and voice operation. Other remote-operating positions, if used, may be set up for test operation in the same manner.

3-95. Apply power to Remote Control Console CY-161/FRC. Depress the number one TRANSMITTER SELECTOR switch. This should bring transmitter to readiness for operation. As the TRANSMITTER SELECTOR switch is depressed, its corresponding signal lamp on each console should become illuminated. Repeat this procedure with as many selector switches as are used. Tests of the RECEIVER SELECTOR switches, the dual-channel amplifier, and the keying oscillator can be made by connecting a jumper pair between the output terminals of transmitter No. 1 and the various receiver

Hence, all the above circuits are directly controllable by the STANDBY switch, S5, located on the control panel on the front of the transmitter.

4-32. Before plate and screen potentials can be applied to the various stages in the transmitter, the thermostat switch, A4, the bias-protection relay, E2, and the requisite CHANNEL switch in the power rectifier must be closed. The primaries of transformers T5 and T7 are energized when this closed circuit is established. Transformer T5 provides filament power for the power amplifier. Transformer T7 applies plate power to the 600-volt mercury-vapor rectifiers, V13 and V14.

CAUTION

If the transmitter is operating in locations where the ambient temperature is likely to be below 0° F (—17.8° C), the filament switch should be turned on at least two minutes before any channel key is closed. This permits the JAN 866A/866 mercury-vapor tubes, which have no other time-delay protection, to come up to operating temperature. Additional time delay should be provided if new mercury-vapor tubes are being installed, under any temperature conditions.

When the CHANNEL switch is closed, the channel-on indicator lamp, located across the primary of transformer T7, will light.

4-33. A supply of +1600 volts for the power-amplifier tubes, V6 and V7, is fed in by a single line through receptacle J2. The transmitter is provided with interlock circuits for the protection of personnel from this high potential. INTERLOCK switch S4 (located on the control panel on the front of the transmitter) and interlock S6 (a push-button type), are paralleled in the transmitter and their leads are connected to terminals 1 and 2 of receptacle J1. This line then passes to all other transmitters to provide a series circuit consisting of all terminals 1 and 2. The INTERLOCK front-panel control switch is provided to disable the interlock for inspection or adjustment of the transmitter when its slide-out chassis is in the "pulled-out" position.

4-34. In the event of excessive (500 milliamperes or more) cathode current in the power-amplifier tubes, the overload section of the special relay, E3, will be actuated, and its contacts will open the circuit to the time-delay relay, E202 (located in the power rectifier). This relay, in turn, opens the primary of the transformer supplying the plate potential to the 1600-volt rectifier tubes. As soon as the plate voltage is removed from the power amplifiers, the current through E3 will drop to zero, and the overload contacts will close and cause the time-delay relay to recycle. If the cause for overload still exists, the cycling operation will repeat itself. The underload section of this special relay is actuated by insufficient (300 milliamperes or less) current passing through the power-

amplifier tubes. Contacts of this section bias the modulator tubes heavily by the insertion of a cathode resistor, and damage to the modulation transformer of that circuit is prevented.

4-35. RADIO TRANSMITTER T-5/FRC (L-F TRANSMITTER).

4-36. The overall stage arrangement of the l-f transmitter is similar to that of the h-f transmitter as described in paragraphs 4-8 through 4-34. Circuit differences exist within certain stages, and when this occurs, the stage concerned is treated specifically. In other cases, where the similarity would involve unnecessary repetition, reference should be made to the corresponding stage in the detailed circuit analysis of Radio Transmitter T-4/FRC. The l-f transmitter provides a nominal power output of 800 watts. It is designed for voice, m-c-w, and c-w emission, and can also be used for frequency-modulation as effected by teletype excitation. Output circuits are designed for operation into a 600-ohm load, as in the T-4/FRC, but since normal operation involves radiation from a vertical antenna whose characteristic impedance is approximately 5-10 ohms, an antenna tuning unit, supplied as a part of each l-f transmitter, must be used to effect optimum transfer of power. The l-f transmitter incorporates an automatic high-voltage disconnect switch and bleeder assembly in place of safety interlock and interlock shunt switches, so that the r-f power amplifier and exciter stages are inoperative when the l-f transmitter is withdrawn from the cabinet. A block diagram of Radio Transmitter T-5/FRC is shown in figure 4-10.

4-37. DETAILED CIRCUIT ANALYSIS.

4-38. MASTER OSCILLATOR AND CRYSTAL OSCILLATOR-DOUBLER. Except for the relative values of circuit parts, the master oscillator and the crystal oscillator-doubler stage of the l-f transmitter are identical with those of the h-f transmitter. (Refer to paragraphs 4-14 through 4-16.)

4-39. INTERMEDIATE POWER AMPLIFIER. This stage (figure 4-11) provides voltage amplification for the small r-f oscillations passing from the oscillator stage. Its operational function is different from that of the T-4/FRC circuit only in that no frequency multiplication occurs. A JAN 807 tetrode is used in a conventional circuit in which the plate tank is tuned by means of the IPA PLATE TUNE variometer-type inductance, L307, and capacitors C317, C318, C319, and C320. This is in contrast to the untuned plate circuit of the intermediate power amplifier in the T-4/FRC. A fixed screen potential is supplied and maintained constant by the 210-volt, regulated power supply located on the T-5/FRC chassis. With the exception of the master oscillator and the crystal oscillator-doubler stages, the stages of the l-f transmitter are tuned by varying plate and grid tank variometers, and by connecting additional capacitors to resonate the tank inductances throughout the frequency range of the transmitter (150 to 550 kilocycles). In all respects except those described above, this stage is similar to the intermediate power amplifier in the h-f transmitter.

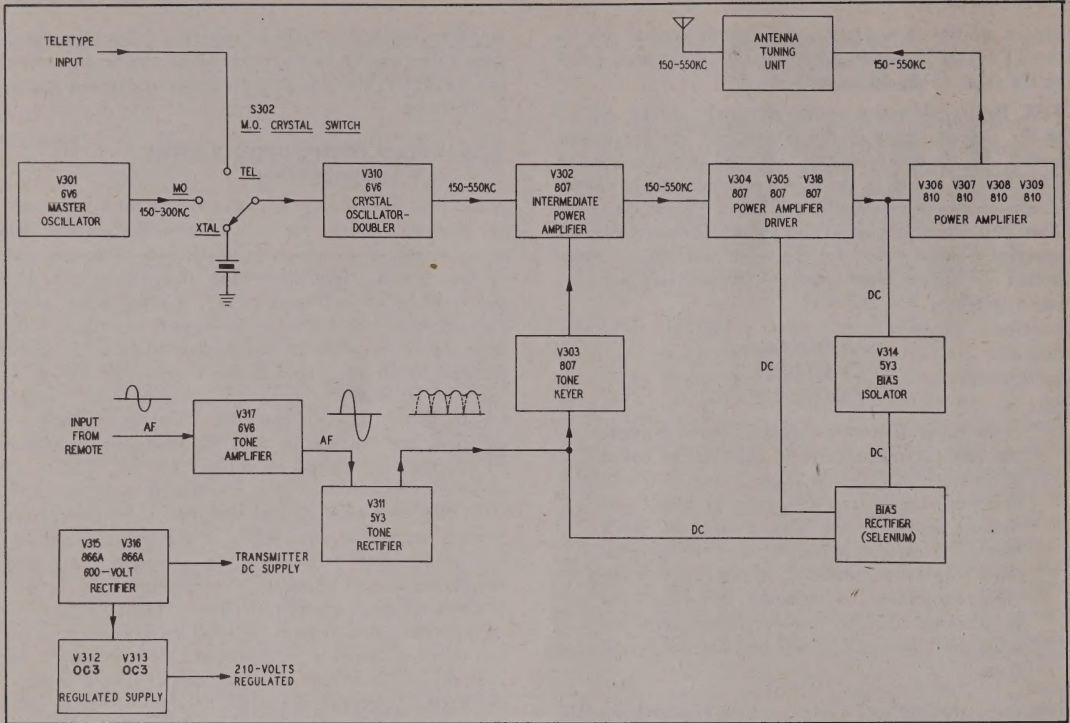


Figure 4-10. Radio Transmitter T-5/FRC, Block Diagram

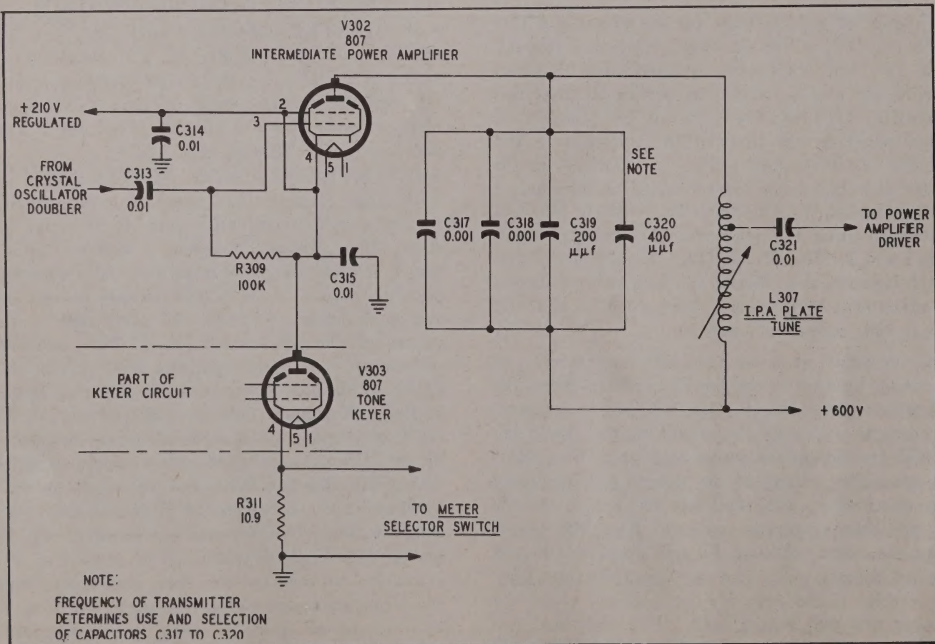


Figure 4-11. Intermediate Power Amplifier, Radio Transmitter T-5/FRC Simplified Schematic Diagram

TABLE 5-7 (Continued)

Step	Equipment Control Positions	Adjust or Set for Normal Indication	Normal Indication	Possible Cause of Abnormal Indication
TUNING ANTENNA TUNING UNIT (Continued)				
14	PLATE to off position. TUNE - OPERATE to OPERATE. PLATE switch to ON.		P.A. PLATE meter indicates approximately 800 milliamperes or less for the desired loading.	Power - amplifier stage, high-voltage rectifier, or Power Rectifier PP-1/FRC
15	TEST to center position. PLATE and channel switch to off position. Close ammeter by-pass switch. Lock all dials, and record settings.			

TABLE 5-8. BAND-SWITCH POSITIONS AND PLUG-IN COIL COMBINATIONS
FOR RADIO TRANSMITTER T-4/FRC

Output Frequency (kc)	Crystal or M-O* Frequency (kc)	M-O* Band Switch Position	Crystal Osc-Doubler Band Switch Position	I-P-A* Coil No.	P-A* Driver Coil No.	P-A* Coil No.	P-A* Air Padders
2000-2300	2000-2300	1	1	1535	1535	1540	In
2300-2441	2300-2441	2	1	1535	1535	1540	In
2441-2800	2441-2800	2	1	1535	1535	1540	Out
2800-2850	2800-2850	3	2	1535	1535	1540	Out
2850-3500	2850-3500	3	2	1536	1536	1540	Out
3500-3516	3500-3516	4	2	1536	1536	1540	Out
3516-3800	3516-3800	4	2	1536	1536	1541	Out
3800-4200	3800-4200	4	3	1536	1536	1541	Out
4200-4545	4200-4545	5	3	1536	1536	1541	Out
4545-5000	4545-5000	5	3	1537	1537	1541	Out
5000-5195	5000-5195	6	3	1537	1537	1541	Out
5195-6000	5195-6000	6	3	1537	1537	1548	Out
6000-7000	3000-3500	3	2	1537	1537	1548	Out
7000-7180	3500-3590	4	2	1537	1537	1548	Out
7180-7573	3590-3787	4	2	1537	1537	1549	Out
7573-7600	3787-3800	4	2	1538	1538	1549	Out

TABLE 5-8 (Continued)

<i>Output Frequency (kc)</i>	<i>Crystal or M-O* Frequency (kc)</i>	<i>M-O* Band Switch Position</i>	<i>Crystal Osc-Doubler Band Switch Position</i>	<i>I-P-A* Coil No.</i>	<i>P-A* Driver Coil No.</i>	<i>P-A* Coil No.</i>	<i>P-A* Air Padders</i>
7600-8400	3800-4200	4	3	1538	1538	1549	Out
8400-9230	4200-4615	5	3	1538	1538	1549	Out
9230-10,000	4615-5000	5	3	1538	1538	1542	Out
10,000-11,720	5000-5860	6	3	1538	1538	1542	Out
11,720-12,000	5860-6000	6	3	1539	1539	1543	Out
12,000-12,600	4000-4200	4	3	1539	1539	1543	Out
12,600-14,850	4200-4950	5	3	1539	1539	1543	Out
14,850-15,000	4950-5000	5	3	1539	1539	1544	Out
15,000-18,000	5000-6000	6	3	1539	1539	1544	Out

* In this and succeeding tables, MO refers to the master oscillator, PA to the power amplifier, and IPA to the intermediate power amplifier.

TABLE 5-9. COIL TAPS (MASTER-OSCILLATOR OPERATION), RADIO TRANSMITTER T-5/FRC

<i>Output Frequency (kc)</i>	<i>M-O Band-Switch Tap No.</i>	<i>Crystal Band-Switch Tap No.</i>	<i>I-P-A Tap No.</i>	<i>P-A Driver Tap No.</i>	<i>P-A Tap No.</i>
150-176	6	3	1-8	1-8	1-6
176-195	5	3	1-8	1-8	1-6
195-216	4	3	2-7	2-7	1-5
216-240	3	3	2-7	2-7	1-5
240-255	2	3	2-7	2-7	1-5
255-266	2	2	3-6	3-6	2-5
266-300	1	2	3-6	3-6	2-5
300-350	6	3	3-6	3-6	2-5
350-370	5	3	3-6	3-6	2-5
370-430	4	3	4-5	4-5	3-4
430-480	3	3	4-5	4-5	3-4
480-500	2	3	4-5	4-5	3-4
500-520	2	2	4-5	4-5	3-4
520-550	1	2	4-5	4-5	3-4

SECTION VI

FIELD AND FASRON MAINTENANCE

6-1. INTRODUCTION.

6-2. This section contains instructions for servicing Radio Transmitters T-4/FRC and T-5/FRC, and associated equipment, at Field and FASRON maintenance levels. Trouble-isolation procedures for the various components of the equipment are given, and certain alignments and adjustments are also included. Instructions for setting up Radio Transmitter T-5/FRC for use as a homing beacon are found in paragraph 6-28, and an overhaul schedule is given in paragraph 6-32.

6-3. TROUBLE ISOLATION.

6-4. TEST PROCEDURES.

6-5. When trouble has been isolated to a component, as determined by the trouble-analysis procedures in table 5-14, reference should be made to the appropriate table of this section. Continuity is necessary when using the trouble analysis and isolation tables. That is, when an equipment failure occurs, table 5-14 should first be referred to, and the directions therein should be followed carefully to determine which table or step at which to proceed next. The same rule applies to tables 6-1 through 6-4. These tables, together with the voltage diagrams found in Section VII, are designed to isolate the faulty circuit and locate the defective part.

WARNING

Before making voltage and resistance checks of components in which there are high voltages, make sure that all power has been removed from the equipment, and that capacitors have been discharged. When measuring voltages, make necessary connections to test equipment before applying power to the equipment. When test has been completed, remove power, discharge capacitors again, and remove test leads.

6-6. When measuring voltages to compare with values given in the voltage and resistance diagrams, a 20,000 ohms-per-volt meter should be used. The modulator chassis is laid out and wired in two halves, identical in electronic circuiting and physical arrangement. For this reason, the voltage diagram for only the right side is given in figure 7-7; values for tubes on the left side are identical.

6-7. PRELIMINARY INSTRUCTIONS.

6-8. Throw the seven toggle switches and the main line switch on the front panel of Power Rectifier PP-1/FRC to the off position. Throw MOD. NO. 2 and MOD. NO. 1 switches to OFF, and all TEST keys to center position. Turn LOCAL-REMOTE switch to LOCAL, STANDBY switch to ON, and INTERLOCK switches to OFF. Pull out of the cabinet the transmitters requiring trouble shooting. Connect ground lead of shorting rod to a good ground, and short all high-voltage connections to ground. Arrange patch cords in patch panel on Power Rectifier PP-1/FRC as desired. Install all necessary crystal and plug-in coils in the transmitting unit. If it is desired to shift frequency at this time, refer to dial-setting charts (figures 5-3 through 5-12) and to table of band-switch positions and plug-in coil combinations, tables 5-8 through 5-12. Throw TUNE-OPERATE switch to TUNE and MICROPHONE switches to LOCAL. Disconnect antenna leads, and connect dummy antenna load (figure 5-2) to antenna posts of the transmitter to be checked. When Radio Transmitter T-5/FRC is pulled forward from the cabinet for trouble-isolation, it is necessary to add two jumpers to the high-voltage disconnect switch and bleeder assembly. Place one insulated jumper across the 220-volt, a-c interlock terminals (located beneath the four bleeder resistors), to obtain plate voltages for the exciter stages and filament voltage for the power amplifier tubes. Connect a second insulated jumper between male and female contacts of the high-voltage disconnect assembly, to provide 1600 volts, dc, for the power amplifier. Turn main line switch S201 on Power Rectifier PP-1/FRC to ON.

CAUTION

If it is desired to test Modulator MD-1/FRC separately from the transmitter, a resistance of the same value as the modulating impedance (2300 ohms or 4600 ohms), and capable of dissipating the full power output of the modulator (300 watts), should be connected across the secondary of the modulating transformer, T103 or T111. If this caution is not observed, the primary impedance of the modulating transformer will rise to a high value, and the audio voltages developed will reach values high enough to break down the transformer insulation. The test oscilloscope should be connected as shown in figure 6-1 to protect it from damage by high voltages in the modulator output.

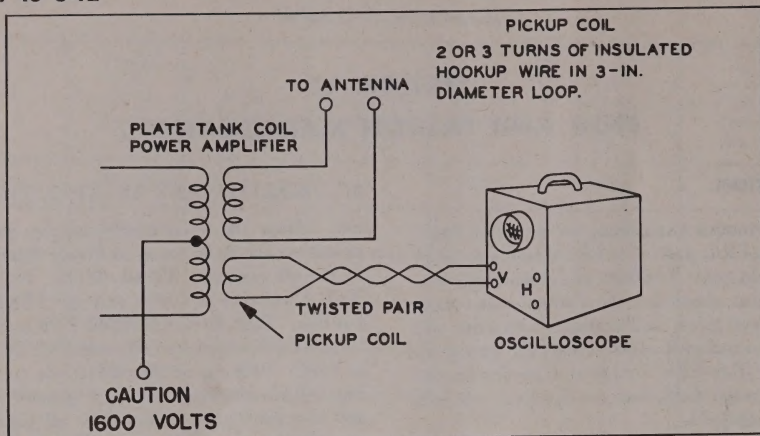


Figure 6-1. Oscilloscope Connections to Transmitter for Obtaining Operating Patterns

6-9. VOLTAGE CHECKS.

6-10. The tube-socket voltage diagrams found in Section VII show the values which should be obtained at tube-socket pin terminals. If a value, as read on a voltmeter, differs beyond reasonable tolerance limits from the value given in the diagram, the amount of variance should be noted and used to help determine which part of the component is at fault. By consulting the schematic diagram

of the component being tested, it is usually not too difficult to locate the defective part. All measurements given in the voltage diagrams were taken with respect to ground, using a 20,000 ohms-per-volt meter.

6-11. TROUBLE ISOLATION TABLES.

6-12. In the following table, test equipment is connected between the test point and ground unless otherwise indicated.

TABLE 6-1. TROUBLE ISOLATION, POWER RECTIFIER PP-1/FRC

Step	Test Point	Test Equipment	Radar Control Settings and Instructions	Normal Indication	If Indication Is Normal	If Indication Is Abnormal
PRIMARY POWER CIRCUITS						
1	I I202 FILA- MENT POWER (figure 6-2)	Visual check	FILAMENTS SWITCH to ON.	Green indicator lamp on left-hand side of HIGH VOLTAGE meter lights.	Primary power is applied and d-c relay power is present. Proceed with step 3.	Check fuses F201, F202, F203, and F206. Check I202. Proceed with step 2.
2	J A201 Center term. of A201 (figure 6-3)	D-C voltmeter; connect between test point and outside terminals of A201.	No change	60 volts	Check relay E201 and switches S202 and S203.	Check selenium rectifier A201 and transformer T201.
3	K I201 PLATE POWER (figure 6-2)	Visual check	TUNE-OPERATE switch to TUNE. PLATE switch to ON.	Red indicator lamp on right-hand side of HIGH VOLTAGE meter lights. Blower motor starts.	Primary power is applied to high-voltage circuits. Proceed with step 4.	Check I201, fuses F204 and F205, and relays E202 and E203.

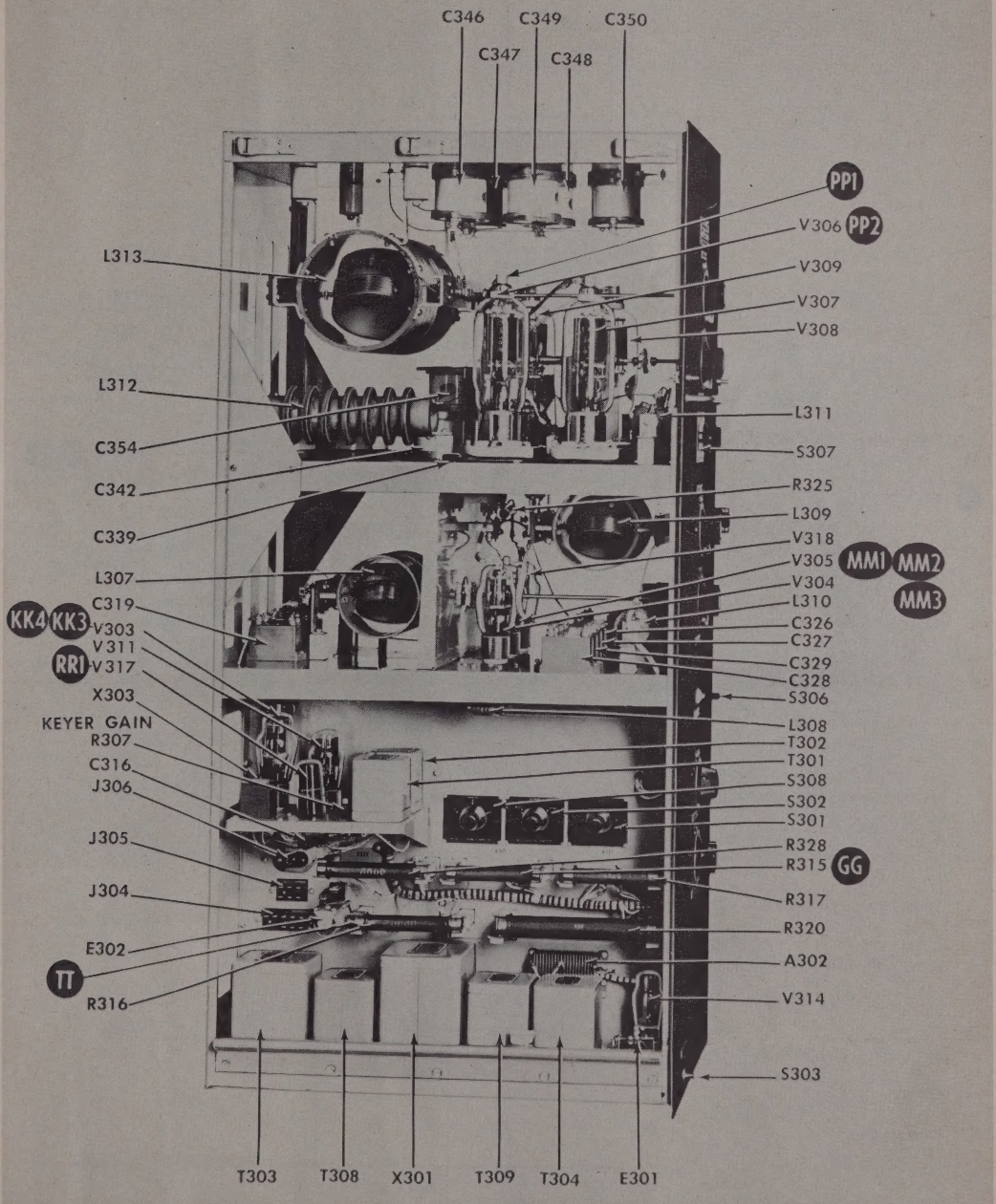


Figure 6-9. Transmitter T-5/FRC, Left Side View

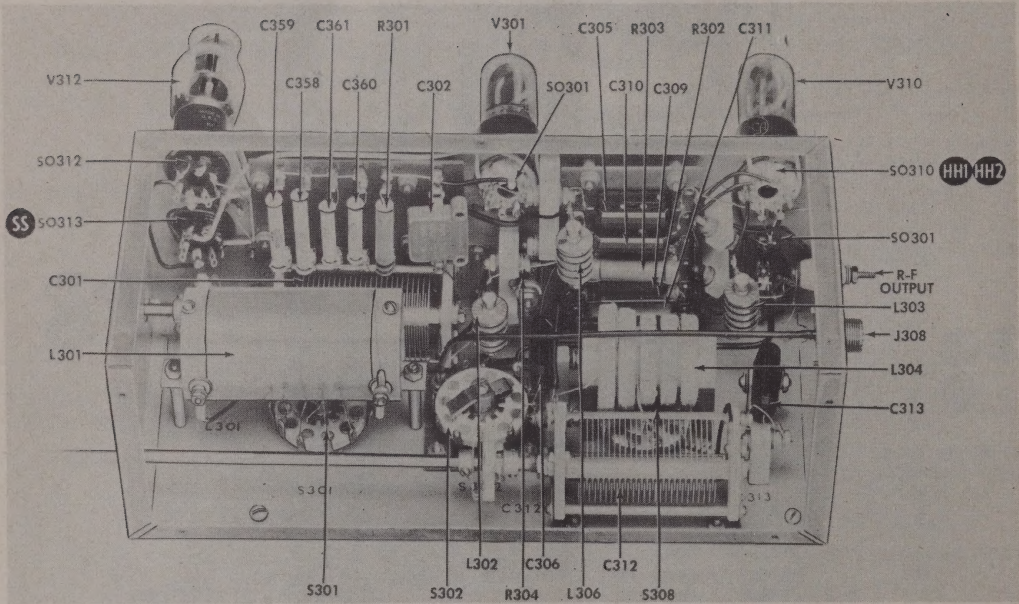


Figure 6-10. Low Frequency Oscillator Assembly

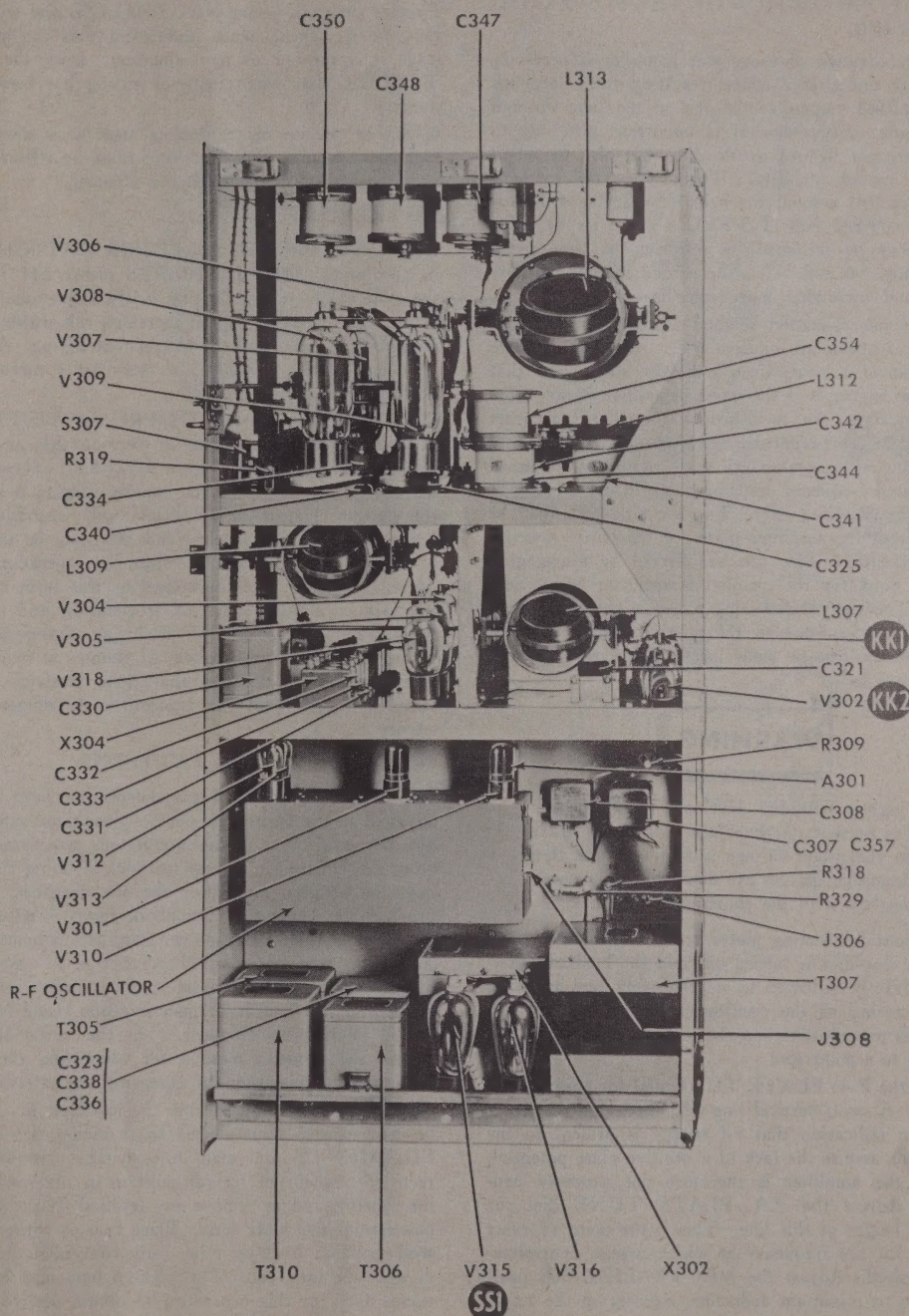


Figure 6-11. Transmitter T-5/FRC, Right Side View

6-13. ADJUSTMENTS.

6-14. NEUTRALIZATION OF THE POWER AMPLIFIER.

6-15. Neutralization of the power amplifier is necessary to eliminate undesirable effects resulting from feedback of the amplified voltage to the grid of the tube through interelectrode capacitance. It is important not only to ensure protection against overloading, but also to obtain maximum circuit stability. There are two methods described in this manual for neutralizing Radio Transmitters T-4/FRC and T-5/FRC. The first of these methods may be followed by reference to the tuning charts, tables 5-6 and 5-7. The second method is more accurate and somewhat more complicated.

6-16. This neutralization method is based on the fact that there is minimum, or zero, r-f current in the plate tank circuit of a neutralized amplifier stage, and that this current increases if the power amplifier is not properly neutralized. An oscilloscope is used for accurate observation of the r-f potential developed across the plate tank circuit. All stages preceding the amplifier are tuned to the desired frequency, and normal grid drive is developed on the amplifier grid. The d-c potential must be removed from the amplifier plate for the entire neutralization procedure. This can be effected by disengaging the patch cord for the channel transmitter being neutralized. The vertical-deflecting plates of the oscilloscope are inductively coupled to the amplifier plate tank by placing the oscilloscope leads inside the plate tank coil, as in figure 6-1.

WARNING

The highest potential developed in this equipment is present on the plate tank coil. Make certain that plate voltage is removed, and that all dangerous charges are dissipated by grounding the coil with the shorting rod.

The horizontal-deflecting plates are not connected. The horizontal amplifier is turned off, and the brilliance control is carefully adjusted to a reasonably low value to prevent burning of the oscilloscope screen in the final step of this procedure, when the oscilloscope presentation is reduced to a point spot.

6-17. Set the P.A. PLATE TUNE dial for approximate resonance. A small vertical line will appear on the scope. This is an indication that r-f energy is present in the plate circuit despite the lack of a positive plate potential, and that the amplifier is therefore not properly neutralized. Adjust the P.A. PLATE TUNE dial for maximum height of this line. This is the point of exact resonance for the frequency at which precise neutralization is desired. Adjust the NEUTRALIZE dial until only a dot, or minimum deflection, appears on the scope. This is the exact point of optimum neutralization. The r-f energy originally fed back through the interelectrode capacitance of the amplifier tubes, has now been com-

pletely cancelled by the equal amount fed back in opposite phase under the control of the neutralizing capacitor. Further variation of the NEUTRALIZE dial will cause the line to appear again, indicating that the amplifier stage is again out of neutralization. Lock the NEUTRALIZE dial when its final setting has been determined.

6-18. For precise neutralization, such as is desired for high-speed keying, this procedure must be repeated each time the transmitter frequency is changed.

6-19. KEYING CHECKS.

6-20. When METER SELECTOR SWITCH S3, is in position 2, MILLIAMPERES meter M1 indicates the amount of current flowing in the keyer-tube cathode circuit. As the keying speed increases, this meter may be observed for indications of inconsistent keying. An oscilloscope, however, provides the basis for a more precise evaluation of keying fidelity.

6-21. Radio Transmitters T-4/FRC and T-5/FRC will produce radiation in the form of clean-cut dots and dashes having rounded edges (figure 6-12(A)). However, if the energy rises or falls too rapidly (figure 6-12(B)), the abrupt changes in amplitude will introduce high-order side-band frequencies, and this may be indicative of circuit disorders and/or improper operation procedures. The side bands developed by this form of radiation are of a wide range of frequencies, and although weak, they are capable of producing considerable disturbance in the form of clicks or thumps in neighboring receivers, despite the fact that these receivers may be tuned to other than the transmitter fundamental frequency.

6-22. MODULATION PATTERNS.

6-23. When the channel transmitter has been properly adjusted to the desired carrier frequency and power output, a careful check of the modulation percentage should be made. There are several methods of doing this. Perhaps the simplest method is the one described in paragraph 5-70, where the microphone input is adjusted for the value of modulator power-amplifier cathode current coinciding with the desired percentage of modulation. However, the most accurate method makes use of the oscilloscope to furnish an instantaneous visual indication at all modulation frequencies in the audio spectrum. Figure 6-1 shows a method for connecting the oscilloscope to the transmitter for observing the patterns.

6-24. Remove all power from the installation. This can be conveniently accomplished by throwing the PLATE, FILAMENTS, and main line switches (inside power-rectifier cabinet) to the off position in that order. Use the shorting rod to remove any residual charge from the power-amplifier plate tank. Place two or three turns of well-insulated hook-up wire (any convenient gauge) in or near the tank coil. This pick-up loop may be repositioned later in this procedure to obtain desired vertical height of the oscilloscope presentation. Attach the terminals of the pick-up loop to the vertical-deflecting plates of the oscilloscope.

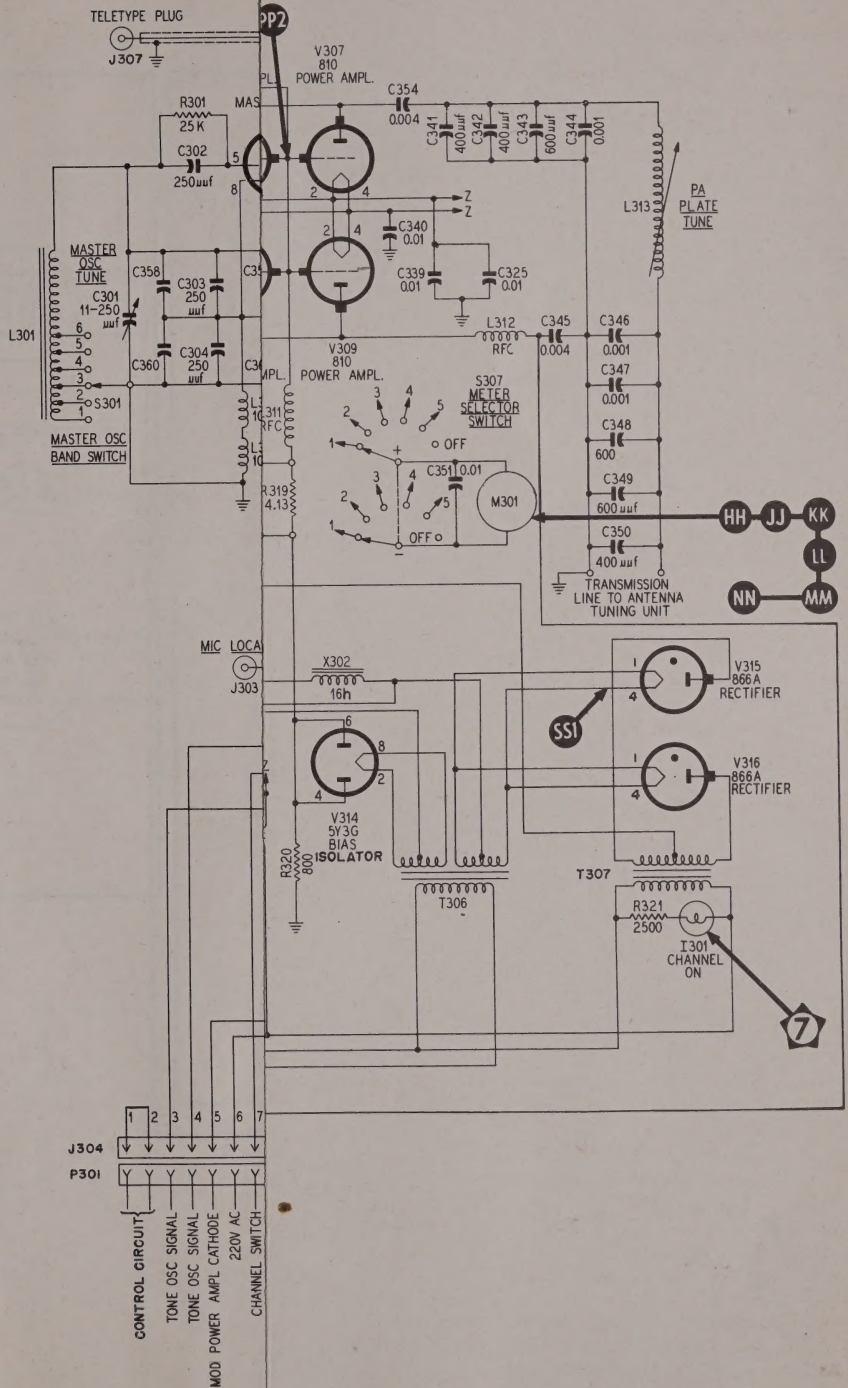


Figure 2

6-13. ADJUSTMENTS.

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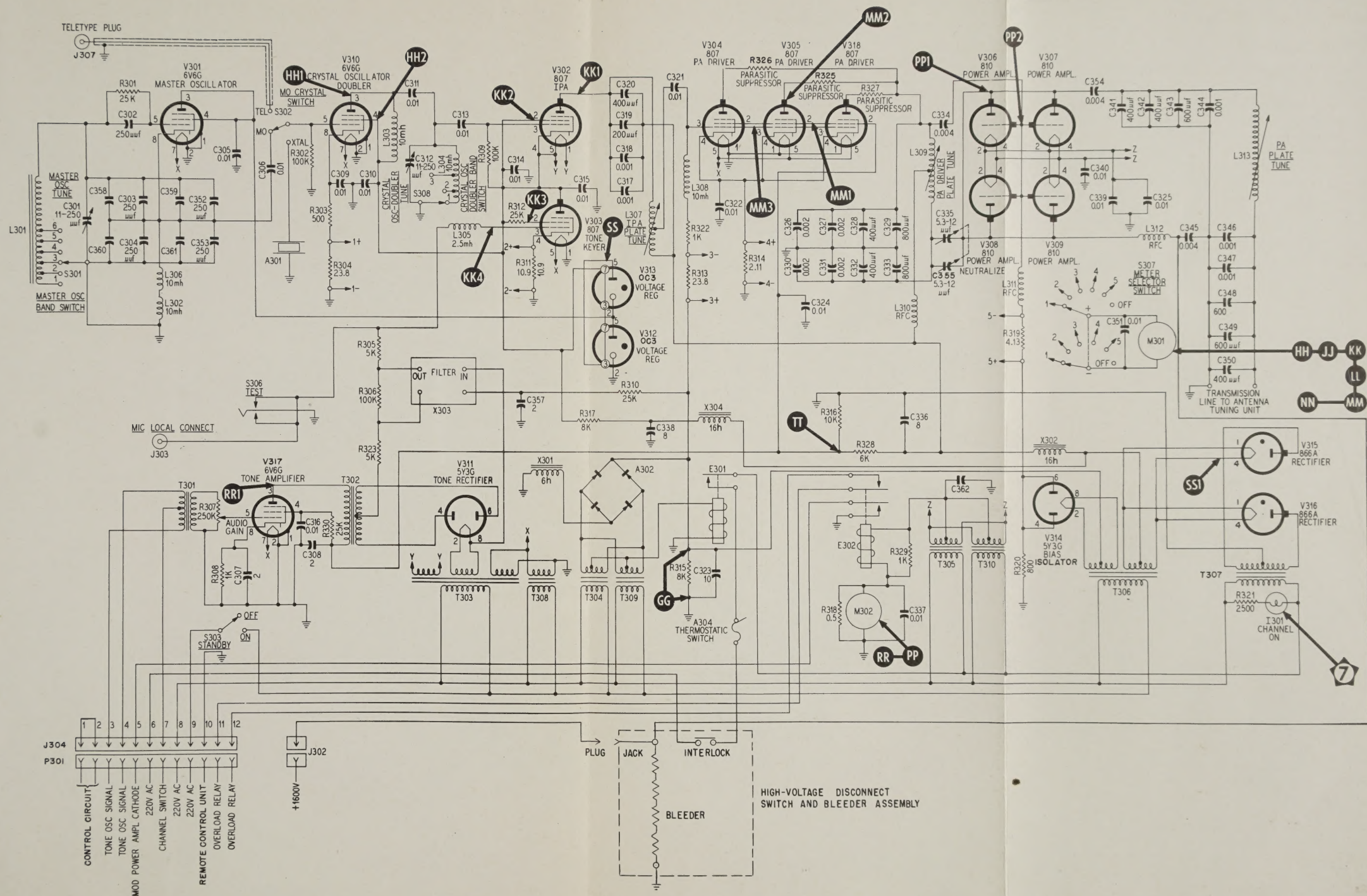
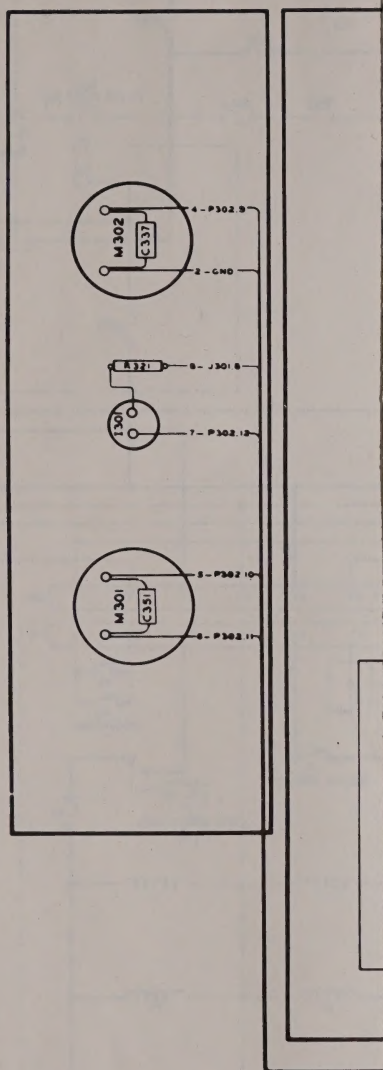


Figure 7-5. Radio Transmitter T-5/FRC, Schematic Diagram



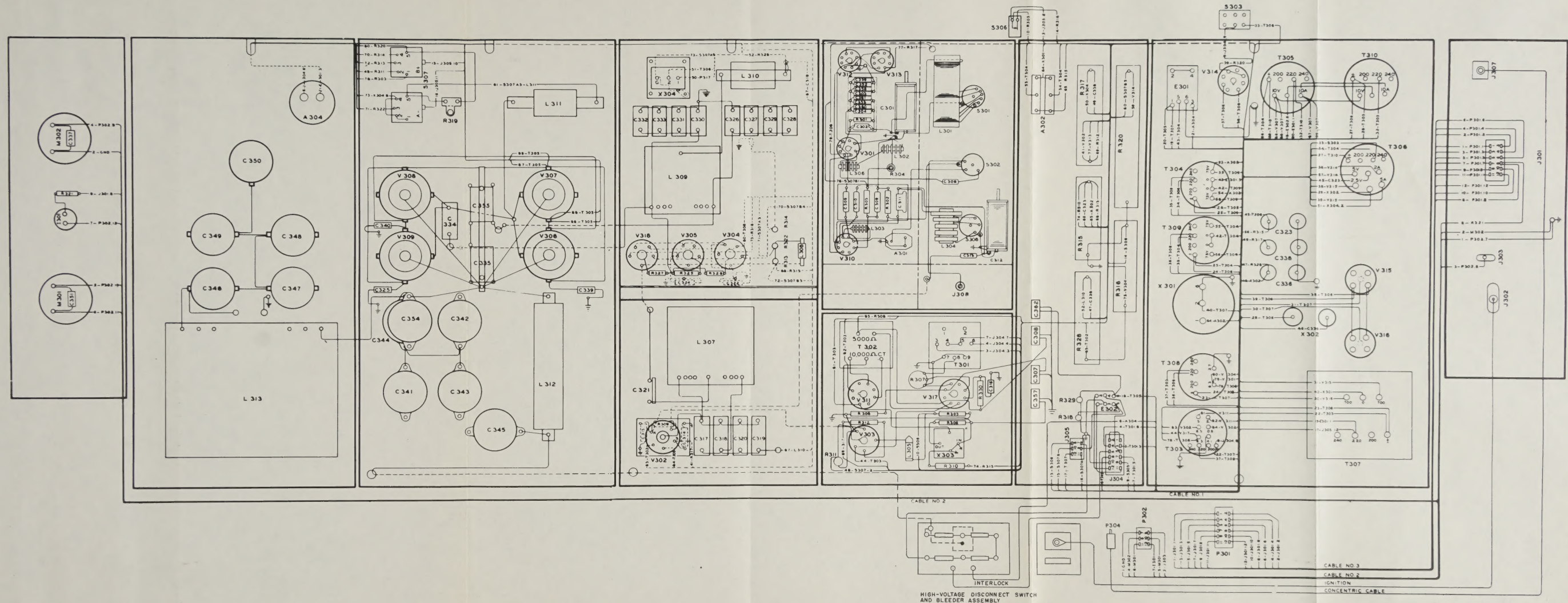


Figure 7-6. Radio Transmitter T-5/FRC, Wiring Diagram

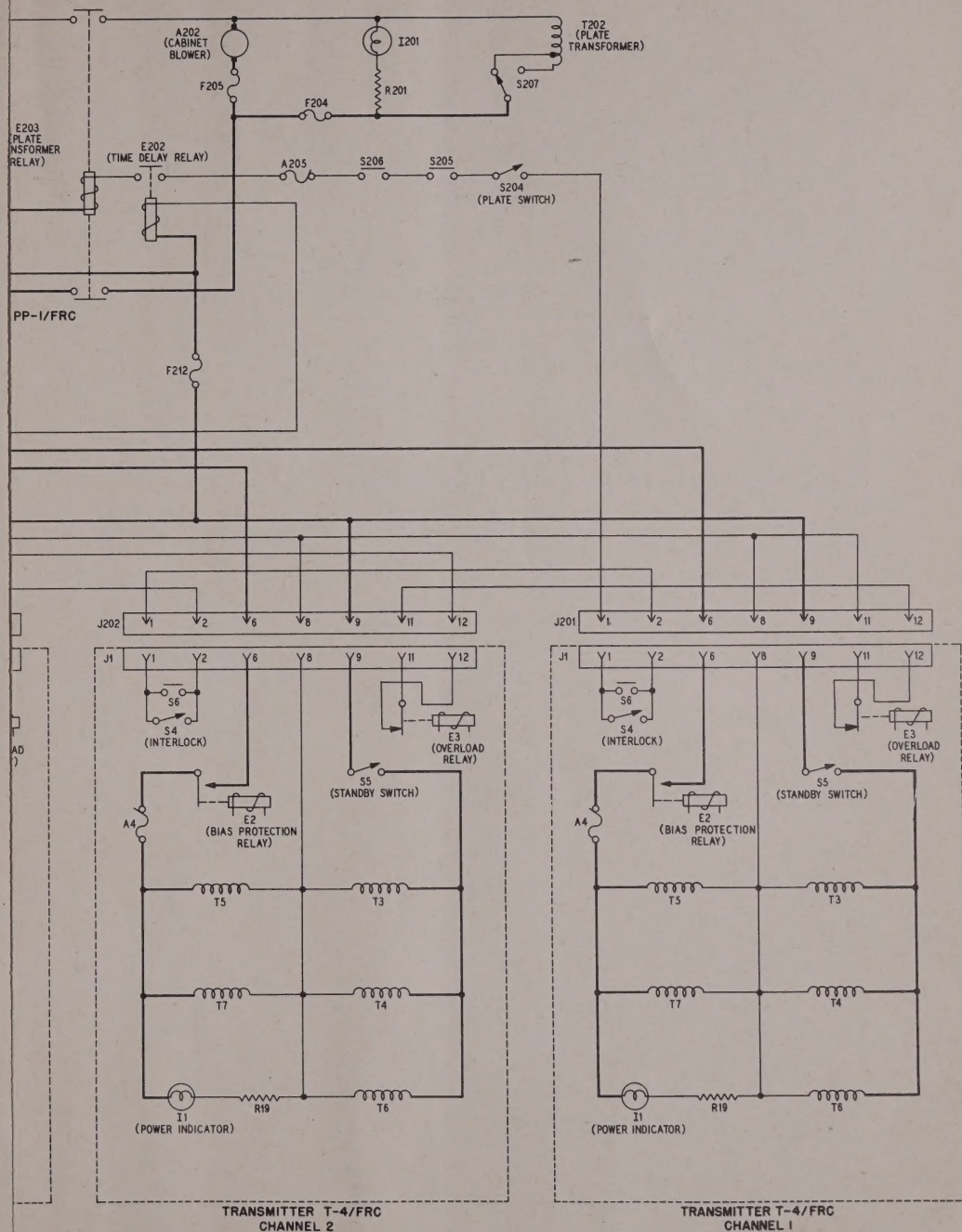
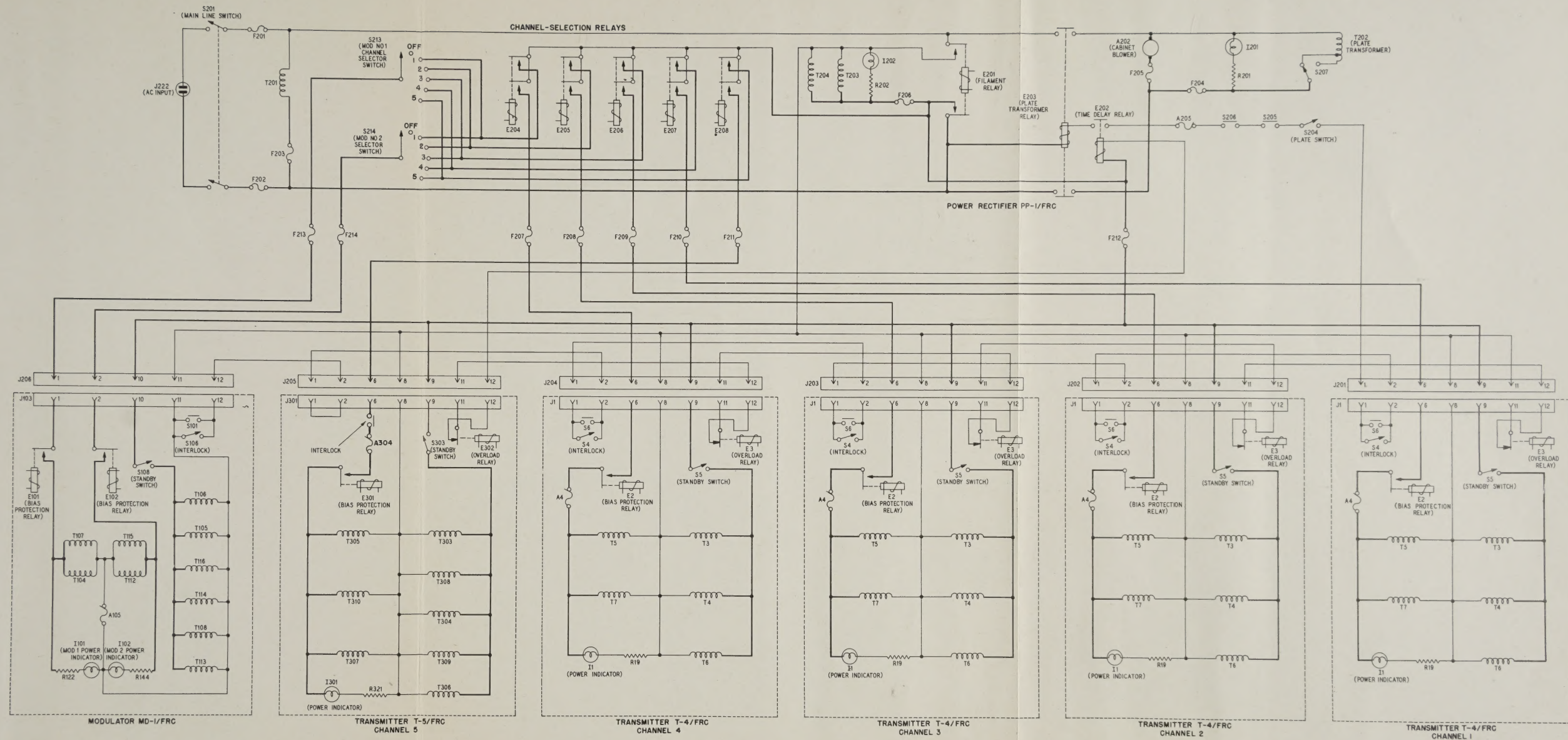


Figure 7-15. A.C. Power Distribution and Control, Schematic Diagram



INDEX (Continued)

	Page		Page
Transmitter T-5/FRC (<i>continued</i>)		Trouble Analysis	97
description of	4	Trouble Isolation	
detailed circuit analysis	51	Modulator MD-1/FRC	108
general analysis	51	Power Rectifier PP-1/FRC	104
high-voltage disconnect switch and bleeder		preliminary instructions	103
assembly	51	Radio Transmitter T-4/FRC	113
homing beacon, use as	127	Radio Transmitter T-5/FRC	120
illustrations		test procedures	103
antenna tuning unit, front view	7	voltage checks	104
front view	8	Tube, Fuse, and Indicator-Lamp Complement...	13, 16
left side view	123	Tuning Procedures	
low frequency oscillator assembly	124	Radio Transmitter T-5/FRC	79
right side view	125	Radio Transmitter T-4/FRC	77
installation of	32		
output frequency versus tank capacity	83	V	
schematic diagram	137-138	Vacuum Tubes	69, 96
trouble isolation	120	Voltage Checks	104
tube, fuse and indicator-lamp complement	13		
tube socket voltage diagram	135-136	W	
tuning procedure	79	Weekly Inspection	72
wiring diagram	139-140		

